LARGE-SCALE OPTIMIZATION

Gordon H. Bradley, Professor
Gerald G. Brown, Professor
R. Kevin Wood, Associate Professor
Department of Operations Research
Sponsor: Air Force Office of Scientific Research

OBJECTIVE: This continuing research program develops theory and algorithms to model and solve large-scale decision support problems.

SUMMARY: Persistent modeling has been extended and demonstrated with a number of applications. New bounds on solution quality of stochastic linear programs have been established. Distributed network decision support has been incorporated into a prototypic network optimization toolkit. Air Force applications include munitions planning, aircraft procurement planning, sortie optimization, and base closing and realignment.

PUBLICATIONS:

Brown, G., Dell, R., and Wood, R.K., "Optimization and Persistence," *INTERFACES*, 27, pp. 15-37, 1997.

Brown, G. and Ronen, D., "Consolidation of Customer Orders Into Truckloads at a Large Manufacturer," *Journal of Operations Research Society*, 48, pp. 779-785, 1997.

Brown, G., Cormincan, K., Lawphongpanich, S., and Widdis, D., "Optimizing Submarine Berthing with a Persistence Incentive," *Naval Research Logistics*, 44, pp. 301-318, 1997.

Buttrey, S.E. and Bradley, G., "Dynamic, Interactive Statistical Research Papers on the Web," Naval Postgraduate School Technical Report, NPS-OR-97-019, December 1997.

Wood, R.K. and Morton, D., "Restricted-Recourse Bounds for Stochastic Linear Programming," *Operations Research* (to appear) 1998.

Wood, R.K., Cormican, K., and Morton, D., "Stochastic Network Interdiction," *Operations Research* (to appear) 1998.

Wood, R.K. and Morton, D., "On a Stochastic Knapsack Problem and Generalizations," *Advances in Computational and Stochastic Optimization, Logic Programming and Heuristic Search*, pp. 149-168, D.L. Woodruff, (ed.), Carmel, CA, 7-9 January 1998.

CONFERENCE PRESENTATIONS:

Bradley, G., "Java: Introduction and Short Tutorial INFORMS National Meeting, San Diego, CA, 4-7 May 1997.

Bradley, G., Jackson, L.A., and Stork, K.A., "A Java Library for Network and Graph Algorithms," INFORMS National Meeting, San Diego, CA, 4-7 May 1997.

Bradley, G. and Buss, A.H., "Loosely Coupled Components for Dynamic Map-Based Planning and Scheduling," DARPA/Rome Laboratory Planning Initiative Workshop, Boston, MA, 11 June 1997.

Bradley, G. and Moriarty, S., "Loosely Coupled Components: Architecture for Dynamic Map-Based Military Planning Systems Using Platform Independent Software Technologies," MITRE Corporation, Reston, VA, 3 September 1997.

Bradley, G., "Java Applications in Modeling and Simulation," Conference on Intelligence Modeling and Simulation: Accomplishments and Challenges, Fort Gordon G. Meade, MD, 24 October 1997.

Bradley, G. and Buss, A.H., "Java for Dynamic Distributed Military Planning Systems," Conference on Intelligence Modeling and Simulation: Accomplishments and Challenges, Fort Gordon G. Meade, MD, 24 October 1997.

Bradley, G., Tutorial: "Java - Introduction and OR Applications," Conference on CS and OR: Recent Advances in the Interface Meeting, Carmel, CA, 7-9 January 1998.

Bradley, G., "Map-Based Dynamic Planning Systems in Java," INFORMs International Meeting, Tel Aviv, Israel, 28 June–1 July 1998 (to be presented).

Wood, R.K. and Morton, D.P., "A Polynomial-Time Solution to a Stochastic Maximum Flow Problem," INFORMS National Meeting, Dallas, TX, 26-29 October 1997.

Wood, R.K., "Generalizing the Generalized Assignment Problem," Conference on CS and OR: Recent Advances in the Interface Meeting, Carmel, CA, 7-9 January 1998 (to be presented).

Wood R.K. and Morton, D., "On a Stochastic Knapsack Problem and Generalizations," Conference on CS and OR: Recent Advances in the Interface Meeting, Carmel, CA, 7-9 January 1998 (to be presented).

THESES DIRECTED:

Appleget, Jeff, "New Cutting-Plane and Constraint Branching Methods for Solving Mixed Integer Programs," Doctor of Philosophy Dissertation, Naval Postgraduate School, June 1997.

Derbes, Henry D., "Efficiently Interdicting a Time-Expanded Transshipment Network," Master's Thesis, Naval Postgraduate School, September 1997.

Karasakal, Orhan, "A Nonlinear Optimization for Planning Procurement and Use of Aircraft and Air-Dropped Munitions, and for Allocating Air Defense Suppression: The Enhanced Strike Model," Master's Thesis, Naval Postgraduate School, March 1997.

Moriarty, Sean T., "A Technical Demonstration of a Map-Based Logistics Planning Tool," Master's Thesis, Naval Postgraduate School, September 1997.

McCarty, Robert T., "Re-Assigning Homeports for United States Coast Guard Medium and High Endurance Cutters," Master's Thesis, Naval Postgraduate School, September 1997.

Rehber, Devrim, "Model Management Via Dependencies Between Variables: An Indexical Reasoning in Mathematical Modeling," Master's Thesis, Naval Postgraduate School, March 1997.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation, Other (Optimization and Decision Support)

KEYWORDS: Optimization, Large-Scale Optimization, Stochastic Optimization

FORECASTING THE RETENTION OF NAVAL AVIATORS

Samuel E. Buttrey, Assistant Professor
William K. Krebs, Assistant Professor
Department of Operations Research
Sponsor: Naval Air Systems Command

OBJECTIVE: To examine the rates at which Naval and Marine Corps aviators are leaving the service in order to forecast future aviator strength.

SUMMARY: In recent years, Naval aviators have been leaving the service faster than retention models would predict. This has raised concerns about the Navy's ability to maintain needed strength levels in coming years. Some of this attrition is presumably due to hiring by civil airlines in a strong economy; other, possibly to disenchantment with flight bonuses or other compensation issues or with perceived changes in the social structure of the Navy. A survey was developed and distributed to some 2,000 Naval aviators, asking them to comment on these and other matters. Additional data comes from the Officer Master File, from other Naval sources, and from civil aviation. Armed with this data a model will be produced that forecasts aviator retention as well as reveals actions the Navy might take to improve it.

DoD KEY TECHNOLOGY AREA: Manpower, Personnel, and Training

KEYWORDS: Aviators, Retention, Force Forecasting

CONSTRUCTING CHARACTERISTIC GROUPS FOR ARMY RECRUITS

Samuel E. Buttrey, Assistant Professor
Harold J. Larson, Professor
Siriphong Lawphongpanich, Associate Professor
Department of Operations Research
Sponsor: U.S. Army Deputy Chief of Staff for Personnel

OBJECTIVE: To categorize Army recruits into homogenous groups based on demographic characteristics in order to reduce variability in strength forecasting.

SUMMARY: The Army divides its recruits in Characteristic Groups ("C-groups") based on demographic measurements like AFQT score, gender, age, and race. It is hoped that these C-groups will consist of individuals who are homogeneous in their propensity to complete their first term of service, and that the groups would differ one from another in this regard. Such groupings could then be used as inputs to a forecasting model that would help predict attrition and therefore recruiting requirements. However, the current set of C-groups does not have these desirable properties. The method of Classification and Regression Trees (CART) is being used to construct C-groups that are as close as possible to optimal, in that their construction maximizes some measure of within-group "purity."

DoD KEY TECHNOLOGY AREA: Manpower, Personnel, and Training

KEYWORDS: CART, C-Groups, Retention, Force Forecasting

OPTIMIZATION MODELS FOR INSTALLATION MANAGEMENT

Robert F. Dell, Associate Professor
Department of Operations Research
Sponsor: U.S. Army Base Realignment and Closure Office

OBJECTIVE: To develop optimization models to assist with installation management.

SUMMARY: The investigator is providing research, support, and development of optimization models to assist the Army's Base Realignment and Closure Office (BRACO). There were three modeling efforts at different levels of development in 1997: (1) continued refinement to BRACAS (Base Realignment and Closure Action Scheduler), an optimization model developed by the investigator and used extensively by BRACO; (2) initial development of an optimization model to assist with allocation of installation operating budgets; and (3) initial development of an optimization model to assist with allocation of environmental clean-up budgets.

PUBLICATIONS:

Brown, G.G., Dell, R.F., and Wood, R.K., "Optimization and Persistence," *Interfaces*, Vol. 27, No. 5 pp. 15-37, September/October 1997.

Dell, R.F., "Optimizing Army Base Realignment and Closure," accepted for publication in *Interfaces*.

CONFERENCE PRESENTATIONS:

Dell, R.F., "Optimizing Base Realignment and Closure Implementation," National Meeting of the Institute for Operations Research and the Management Sciences, San Diego, CA, 4-7 May 1997.

Dell, R.F., "Managing the Environmental Costs of Closing U.S. Army Bases," 16th International Symposium on Mathematical Programming, Lausanne, Switzerland, 24-29 August 1997.

THESIS DIRECTED:

Bridges, M., "Optimally Funding Army Installation Repair and Maintenance Activities," Master's Thesis, Naval Postgraduate School, September 1997.

DoD KEY TECHNOLOGY AREA: Other (Optimization)

KEYWORDS: BRAC, Capital Budgeting, Optimization, Mixed Linear Integer Programming Application

DYNAMICAL, APPLIED PROBABILITY AND STATISTICAL MODELING IN TOXICOLOGICAL AND ENVIRONMENTAL PROBLEMS

Donald P. Gaver, Distinguished Professor
Patricia A. Jacobs, Professor
Department of Operations Research
Sponsors: Operations, Test, and Evaluation Force and Naval Postgraduate School

OBJECTIVE: To conduct mathematical research in applied probability modeling and evaluation of procedures of operational test and evaluation and quantitative toxicology. The models usefully supplement, or even replace, certain large-scale time-consuming simulations. They have implications for joint operational situations.

SUMMARY: Models of organic cell response to toxins have been proposed and assessed using experimental results. Models for studying the allocation of units to destructive testing when the total number of units is fixed have been developed and studied. Models to predict operational test performance from developmental test results have been proposed and studied.

PUBLICATIONS:

Gaver, D.P. and Jacobs, P.A., "Testing or Fault-Finding for Reliability Growth: A Missile Destructive-Test Example," Naval Postgraduate School Technical Report NPS-OR-97-009, May 1997.

Gaver, D.P., Jacobs, P.A., and Fries, A., "Prediction of Changeover Performance: Operational Test (OT) Parameters from Developmental Test (DT) Parameters Via Meta-Analysis," Naval Postgraduate School Technical Report, NPS-OR-97-012, August 1997.

Gaver, D.P. and Jacobs, P.A., "Testing or Fault-Finding for Reliability Growth: A Missile Destructive-Test Example," *Naval Research Logistics*, 44, pp. 623-637 1997.

Gaver, D.P., Jacobs, P.A., Carpenter, R.L., and Burkhart, J.G., "A Mathematical Model for Intra-Cellular Effects of Toxins on DNA Adduction and Repair," *Bulletin of Mathematical Biology*, 59, pp. 89-106 1997.

Gaver, D.P., Jacobs, P.A., and Fries, A., "Prediction of Changeover Performance: Operational Test Rates from Developmental Test Rates Via Meta-Analysis," *American Statistical Society Proceedings: Government Statistics*, 1997.

Gaver, D.P. and Jacobs, P.A., "Methodology for an Operationally-Based Test Length Decision," Naval Postgraduate School Technical Report, NPS-OR-97-015, August 1997. Accepted for publication in *IIE Transactions on Quality and Reliability.*

Verhaar, H.J.M., Morroni, J.S., Reardon, K.F., Hays, S.M., Gaver, D.P., Carpenter, R.L., and Yang, R.S.H., "A Proposed Approach to Study the Toxicology of Complex Mixtures of Petroleum Products: The Integrated Use of QSAR, Lumping Analysis and PBPK/PD Modeling," *Environmental Health Perspectives*, Vol. 105 Supplement 1, January 1997.

CONFERENCE PRESENTATIONS:

Carpenter, R.L., Gaver, D.P., Narayanan, T.K., Jacobs, P.A., and Jung A., "A Mathematical Model of Cell Toxicity: Comparison with Cell Culture Results," Poster Session: Liver/Gastrointestinal System, 36th Annual Meeting of the Society of Toxicology, Cincinnati, OH, 9-13 March 1997.

Gaver, D.P., Jacobs, P.A., and Fries, A., "Prediction of Changeover Performance: Operational Test Rates from Developmental Test Rates Via Meta-Analysis," Joint Statistical Meetings, Anaheim, CA, 10-14 August 1997.

THESES DIRECTED:

Dippery, K.L., "Changeover Inference: Estimating the Relationship Between DT and OT Data," Master's Thesis, Naval Postgraduate School, March 1997.

Gorman, J.R., "Operationally-Relevant Test Lengths: A Decision-Analysis Approach," Master's Thesis, Naval Postgraduate School, March 1997.

Hone, A.B., "TRICARE Versus FEHBP: A Pilot Study of Comparative Inpatient Costs in Region 1," Master's Thesis, Naval Postgraduate School, June 1997.

McGoff, D.A., "Analysis to Support Hazardous Waste Management Re-Engineering at Lawrence Livermore National Laboratory," Master's Thesis, Naval Postgraduate School, September 1997.

OTHER:

Gaver, D.P. and Jacobs, P.A., "Waiting Times When Service Times are Stable Laws: Tamed and Wild," *Recent Contributions in Applied Probability and Stochastic Processes*, accepted for publication.

Gaver, D.P., Carpenter, R.L., Narayanan, T.K., Jacobs, P.A., and Jung, A., "A Mechanistic Model of Cell Toxicity from APAP," forthcoming.

Gaver, D.P., Jacobs, P.A., and Carpenter, R.L., "Stochastic Models for Cell Signaling and Toxic Effects on Cells," forthcoming.

Gaver, D.P., Jacobs, P.A., and Dudenhoeffer, D.D., "Failure, Repair, and Replacement Analysis of a Navy Subsystem: Case Study of a Pump," Proceedings of the Seventh International Symposium on Applied Stochastic Models and Data Analysis, pp. 201-210. (to appear in *Applied Stochastic Models and Data Analysis).*

DoD KEY TECHNOLOGY AREAS: Human System Interface, Environmental Quality

KEYWORDS: Stochastic Models, Dose-Response Models, Biological Cells, Toxic Chemicals, Bioassay, Operational Testing

RESEARCH IN JOINT WARFARE MODELING AND SIMULATION, EMPHASIZING INFORMATION WARFARE ISSUES

Donald P. Gaver, Distinguished Professor
Patricia A. Jacobs, Professor
Lt Col Mark A. Youngren, Assistant Professor
Department of Operations Research
D. Scott Davis, Associate Professor
Department of Physics
Sponsors: Conventional Forces Analysis Division, J-8, The Joint Staff, Naval Postgraduate School-Institute for Joint Warfare Analysis, and Chief of Naval Operations Strategic Planning Office

OBJECTIVE: The purpose of the research is to adapt, extend, and enhance capabilities of Future Theatre Level Model Architecture to joint arenas. The emphasis is on modeling the impact of information obtained from realistically imperfect sensor systems on interactive and joint conflicts.

SUMMARY: New models for the effect of Battle Damage Assessment on Targeting have been formulated and studied. The effect of various levels of sensor effort on combat has been and is being modeled in various scenarios.

PUBLICATIONS:

Davis, D.S., "Basic Physics of Target Sensing for Joint Theater-Level Models of the Future," forthcoming.

Gaver, D.P., Jacobs, P.A., and Youngren, M.A., "Analytical Models for Battlespace Information War (BAT-IW) Parts 1 and 2," forthcoming.

Gaver, D.P., Jacobs, P.A., and Youngren, M.A., "Binomial-like Sensors," in progress.

Gaver, D.P., Jacobs, P.A., Youngren, M.A., and Parry, S.H., "Models for Force Interaction That Involve Uncertain Perception," forthcoming.

Gaver, D.P. and Jacobs, P.A., "Attrition Modeling with Decoys: An Operations Other Than War (OOTW) Motivation," *Naval Research Logistics*, Vol. 44, No 5, pp. 507-514, August 1997.

Gaver, D.P. and Jacobs, P.A., "Probability Models for Battle Damage Assessment (Simple Shoot-Look-Shoot and Beyond)," Naval Postgraduate Technical Report, NPS-OR-97-014, August 1997.

Gaver, D.P. and Jacobs, P.A., "Stochastic and Deterministic Models of Targeting, with Dynamic and Error-Prone BDA," Naval Postgraduate School Technical Report, NPS-OR-97-018, September 1997.

CONFERENCE PRESENTATIONS:

Gaver, D.P., Jacobs, P.A., and Youngren, M.A., "Analytic Representation of Data Fusion in Theater-Level Models," C4I Conference, National Defense University, Fort McNair, Washington, DC, June 1997.

Gaver, D.P. and Jacobs, P.A., "Service Systems with Incomplete or Imperfect Service," INFORMS National Meeting, Dallas, TX, 26-29 October 1997.

OTHER:

Youngren, M., "SCUD Hunting," Visual Basic Software, June 1997.

Uribe, L., "Deep Strike" Pascal Software, December 1997.

DoD KEY TECHNOLOGY AREAS: Human System Interface, Modeling and Simulation

KEYWORDS: Combat Models, Bayesian Perception Updating, Decision Analysis

JOINT LITTORAL WARFARE AND ONGOING PROJECTS

Wayne P. Hughes, Jr., Senior Lecturer
Department of Operations Research
Sponsor: Naval Postgraduate School-Institute for Joint Warfare Analysis

OBJECTIVES: To fine-tune the Joint Campaign Analysis Course OA4602, to edit and publish a technical report, and to initiate research in the role of naval forces in joint littoral warfare.

SUMMARY: The Campaign Analysis Course was revised to embrace joint operations and special warfare. With very major assistance by LCDR Eric Godat and Terri Bilodeau, the textbook and book of readings were completed and tested in class. Because of another change in the Operations Analysis curriculum from eight quarters to seven quarters, the military sequence of which OA4602 is a component will be compressed, involving further changes such as the introduction of "operations other than war."

Editing, preparation of figures, and incorporation of front matter were completed, and *A Concise Theory of Combat* was published by the Institute For Joint Warfare Analysis. It has been distributed to about 300 addressees.

A funded research project for the Naval Doctrine Command was recast and published in the *Naval War College Review* as "Naval Maneuver Warfare." In addition, exploratory analysis was conducted in Arsenal Ship performance and considerations of reduced manning and tactical networking. As Navy emphasis shifted to the performance of the same strike function by other warships, the relative advantage of the competing alternatives was explored in a preliminary way through class projects.

The remainder of the 0.2 research year was devoted to pursuing a revised edition of *Fleet Tactics: Theory and Practice*: One new chapter is written and the Introduction is entirely recast to take into account the tactical properties of operations in the littorals, including logistics, missile warfare, and fire support.

PUBLICATIONS:

Beddoes, M.W., "Logistical Implications of Operational Maneuver From the Sea," *Naval War College Review,* Autumn, pp. 32-48, 1997.

DuBois, E. L, Hughes, W.P., Jr., and Low, L.J., "A Concise Theory of Combat," NPS-IJWA-97-001, The Military Conflict Institute and the Institute for Joint Warfare Analysis, Naval Postgraduate School, Monterey CA, 1997.

Hughes, W.P., Jr. "Naval Maneuver Warfare," *Naval War College Review,* Summer pp. 25-49, 1997.

THESES DIRECTED:

Beddoes, M.W., "Logistical Implications of Operational Maneuver From the Sea," Master's Thesis, Naval Postgraduate School, March 1997.

Dunbar, C. and Pietrantoni, D., "The Arsenal Ship Concept: Vulnerability to Special Operations," Master's Thesis, Naval Postgraduate School, December 1997.

Fleming, M.G., "The Cost and Benefits of Reduced Manning for U.S. Naval Combatants," Master's Thesis, Naval Postgraduate School, March 1997.

Horner, D., "Special Operations Integration in Theater Missile Defense," Master's Thesis, Naval Postgraduate School, June 1997.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Doctrine, Joint Operations, Littoral Warfare, Maneuver Warfare, Naval Tactics, Operational Maneuver from the Sea, Sea Dragon, Arsenal Ship

NITE HAWK SENSOR FUSION DEMONSTRATION

William K. Krebs, Assistant Professor
Department of Operations Research
Sponsor: Office of Naval Research

OBJECTIVE: This study will assess whether a sensor fusion (infrared sensor and a third generation image intensified CCD) targeting pod should be procured for the F/A-18. This sensor fusion targeting system may improve a target's definition and clarity, which, in turn, will improve pilot recognition. This study will also evaluate the optimal spectral band combination (multiple bands from visible to long wave infrared) for all-purpose targeting requirements. If the results of the proposed research indicate that sensor fusion is more effective than current infrared and low-light visible systems, this technology will transition into the existing and future targeting infrared systems.

SUMMARY: A non-real-time color sensor fusion system was flown on a NASA F/A-18 in a NITE Hawk targeting FLIR pod. Flight videotape was recorded from a third generation image intensified CCD and a first generation long-wave infrared sensor. A standard visual search task was used to assess whether pilots' situational awareness was improved by combining the two sensor videotape sequences into a single fused color or grayscale representation. Fleet aviators showed that color fusion improved target detection, but hindered situational awareness. Aviators reported the lack of color constancy caused the scene to be unaesthetically pleasing; however, target detection was enhanced. In summary, a color fusion scene may benefit targeting applications but hinder situational awareness.

CONFERENCE PRESENTATION:

DeFord, J.K., Sinai, M.J., Krebs, W.K., Srinivasan, N., and Essock, E.A., "Perceptual Organization of Color and Non-Color Nighttime Real-World Imagery," Investigative Ophthalmology and Visual Science, (SUPPL) 38, 2998, May 1997.

Essock, E.A., Sinai, M.J., Srinivasan, N., DeFord, J.K., and Krebs, W.K., "Texture-Based Segmentation in Real World Nighttime Scenes," Investigative Ophthalmology and Visual Science, (SUPPL) 38, 2998, May 1997.

THESIS DIRECTED:

Ogawa, J., "Image Assessment of Nighttime Imagery," Master's Thesis, Naval Postgraduate School, September 1997.

DoD KEY TECHNOLOGY AREAS: Sensors, Air Vehicles, Human Systems Interface

KEYWORDS: Sensor Fusion, Targeting, Human Performance

LOW-LIGHT AND INFRARED EVALUATION

William K. Krebs, Assistant Professor
Department of Operations Research
Sponsor: Office of Naval Research

OBJECTIVE: The Navy and Marine Corps F/A-18 pilots state that the targeting FLIR system does not provide enough target definition and clarity. As a result, high altitude tactics missions are the most difficult due to the limited amount of time available to identify the target. If the targeting FLIR system had a better stand-off range and an improved target contrast then the pilots' task would be easier. Unfortunately, the replacement cost of the existing FLIR equipment is prohibitive. The purpose of this study is to modify the existing F/A-18 targeting FLIR system with a dual-band color sensor to improve target contrast and stand-off ranges.

SUMMARY: Several different visual search experiments found that subjects overwhelmingly supported sensor fusion; however, they complained about the color selection of the scenes. Subjects reported that color fused targets had better target contrast, but were not aesthetically pleasing. Perhaps, color fusion should not be used for situational awareness, rather it should be used for targeting. In a targeting task, the operator is not concerned about the object's overall appearance; rather can the target be quickly and accurately detected. Accordingly, color fusion should be intended for targeting applications, not situational applications.

CONFERENCE PRESENTATION:

Therrien, C.W., Scrofani, J., and Krebs, W.K., "An Adaptive Technique for the Enhanced Fusion of Low-Light Visible with Uncooled Thermal Infrared Imagery," IEEE: International Conference on Imaging Processing, October 1997.

DoD KEY TECHNOLOGY AREAS: Sensors, Air Vehicles, Human Systems Interface

KEYWORDS: Sensor Fusion, Targeting, Human Performance

PERCEPTUAL PLASTICITY IN A VIRTUAL ENVIRONMENT

William K. Krebs, Assistant Professor
Department of Operations Research
Sponsor: Naval Postgraduate School

OBJECTIVE: This research is investigating low-level perceptual-adaptation effects caused by long-term exposure to a virtual environment (VE). Subjects in a VE experience various levels of "simulator sickness" of unknown origin. Researchers suspect the sickness is due to a sensory perceptual mismatch between vestibular-occular and somatosensory inputs.

SUMMARY: It is hypothesized that superior colliculus cells will be disrupted or altered during long exposures to a VE display. The head-mounted display (HMD) is configured so that the observer views a projected image in optical infinity. Perhaps, characteristics of the HMD, such as field of view, frame rate, and resolution, may change cells æ referred to as plasticity æ located within the superior colliculus. This superior colliculus plasticity would show the largest manifestations during long exposures to virtual environments. Accordingly once the observer removes the HMD, the superior colliculus cells must adapt to the previous familiar environment. This re-adaptation period does not require an extended amount of time due to the initial hardwiring of the visual cortical system. Thus, long VE exposures would cause longer adaptation periods, which would induce more severe nausea, postural instability, and other simulator induced symptoms.

DoD KEY TECHNOLOGY AREAS: Human Systems Interface, Biomedical, Modeling and Simulation

KEYWORDS: Virtual Environment, Simulator Sickness, Plasticity

HUMAN VISUAL SENSORY MEASUREMENT: RELATIONSHIP TO SEARCH AND DETECTION THEORY

William K. Krebs, Assistant Professor
Department of Operations Research
Sponsor: Naval Postgraduate School

OBJECTIVE: To purchase a Photo Research Spectra Colorimeter model 650 to support the Human Factors option within the Department of Operations Research.

SUMMARY: This device will quantify illuminant/luminanct surface properties for console display design, visual psychophysical experiments, and laboratory and field experiments. So far, the colorimeter has supported several student OA3401, OA3402, and OA4401 class projects. In addition, several thesis students and faculty have used this device to support their research projects.

DoD KEY TECHNOLOGY AREAS: Sensors, Other (Materials, Personnel and Training)

KEYWORDS: Photo Research-650 Spectra Colorimeter

EVALUATION OF COLOR SENSOR FUSION TO IMPROVE TARGET RECOGNITION

William K. Krebs, Assistant Professor
Department of Operations Research
Sponsor: Lockheed Martin Electronics and Missiles Corporation

OBJECTIVE: The primary objective is to demonstrate that a color night vision sensor (combining a FLIR and an image intensified scene into a single displayed image) on the Lockheed Martin NITE Hawk targeting FLIR pod is significantly better for target recognition compared to the existing NITE Hawk targeting pod. Psychophysical visual tests will be performed on experience fleet aviators to determine if the pilot can recognize and detect significantly more targets using the color night vision compared to either a FLIR or image intensified scene. The results of this study will also provide potential performance enhancement for other Lockheed Martin electro-optical platforms.

SUMMARY: A sensor fusion system was successfully demonstrated on a modified NITE Hawk targeting FLIR pod. Several flights used different combinations of electro-optical and visible sensors to determine if a color-fused scene increased pilots' targeting stand-off range compared to a single sensor scene. Human performance results on the situational awareness task did not show color fusion to be superior, however this may have been due to several threats in experimental methodology. The sensor fusion algorithms were not able to adequately correct the registration problems of the images, thus causing many scenes to be spatially distorted. Subject exit interviews overwhelmingly supported sensor fusion; however, they complained about the color selection of the scenes. Subjects reported that color fusion targets had better target contrast, but were not aesthetically pleasing. Perhaps, color fusion should not be used for situational awareness rather it should be used for targeting. Accordingly, color fusion should be intended for targeting applications, not situational applications. This is in agreement with the Army's Night Vision Electronics Sensor Directorate.

CONFERENCE PRESENTATION:

Krebs, W.K., Scribner, D.A., Miller, G.M., Ogawa, J.S., and Schuler, J., "Beyond Third Generation: A Sensor Fusion Targeting FLIR Pod for the F/A-18," International Society for Optical Engineering (SPIE): Sensor Fusion Architectures, Algorithms, and Applications II, 16 April 1998.

THESES DIRECTED:

Ogawa, J., "Evaluating Color Fused Image Performance Estimators," Master's Thesis, Naval Postgraduate School, September 1997.

DoD KEY TECHNOLOGY AREAS: Human Systems Interface, Sensors, Air Vehicles

KEYWORDS: NITE Hawk Targeting Pod, Human Performance, Targeting, Color Night Vision

ECONOMETRIC PROJECTION OF ARMY PERSONNEL STRENGTH

Siriphong Lawphongpanich, Associate Professor
Department of Operations Research
Gregory Hildebrandt, Associate Professor
Department of Systems Management
Sponsor: U.S. Army Deputy Chief of Staff for Personnel

OBJECTIVE: To develop econometric models for forecasting retention rates of Army officers and enlisted personnel.

SUMMARY: The research is officially scheduled to begin in July 1998. The sponsor approved its direction and plan during October 1997. The main goal of this study is to develop econometric models for forecasting retention rates of Army officers and enlisted personnel. These models should include economic, demographic, and service-specific factors relevant to the decision to remain in the Army.

DoD KEY TECHNOLOGY AREA: Other (Econometric Model)

KEYWORDS: Manpower, Retention Rate, Forecasting

ESTIMATION OF RELIABILITY FROM TEST PLAN RESULTS

Robert R. Read, Professor
Department of Operations Research
Sponsor: Naval Surface Warfare Center-Crane Division

OBJECTIVE: To study the models used for estimating the lot reliability of ammunition based solely upon the results of destructive testing, part of which is conducted after sundry types of stresses have been applied to the items.

SUMMARY: The items selected for testing are partitioned into a number of subsets. The units in a subset are subjected to stress, one for each subset. The stresses include vibration, humidity, several temperatures, and no stress at all. Reliability point estimates and lower confidence bounds are required of all lots whose samples pass the test plan schedule. Generally the methods in use and those proposed by others are ultra conservative. That is, the reliability estimates are low and the lower confidence bounds are very low. This creates the awkward situation of marking a lot as acceptable, and yet attaching embarrassingly low reliability figures to it. Apparently there are no resources available to calibrate the failure modes to the extent and severity of the stresses.

The author suggested a log linear modeling technique for the estimation portion of the testing. The results appear to be far less conservative. On the other hand the resulting estimates refer to a less comprehensive reliability function.

PUBLICATION:

Read, R.R., "Reliability Estimation Based Upon Test Plan Results," Naval Postgraduate School Technical Report, NPS-OR-97-013, August 1997.

DoD KEY TECHNOLOGY AREA: Conventional Weapons

KEYWORDS: Reliability, Stressful Testing, Destructive Testing

SURVIVAL ANALYSIS IN LOSS RATE GENERATION

Robert R. Read, Professor
Department of Operations Research
Sponsor: U.S. Army Deputy Chief of Staff for Personnel

OBJECTIVE: To study the effectiveness in using Survival Analysis techniques in the estimation of attrition rates for use in the ELIM module of the U.S. Army personnel flow models and to illustrate the use of covariates in these algorithms.

SUMMARY: The partitioning of the population according to existing C-groups and by cohorts (month of entry) was taken as a given. There are a number of important findings. First there is need to standardize the measures of performance. The present study uses average magnitude of relative error for the sets of forecast cells. Second there is considerable variability in the forecastability of the attrition rates of soldiers in the various C-groups. Third, the logit, probit and exponential smoothing models appear to perform about equally well; the former two have the advantage in that their forecasts can be influenced by the use of covariates using existing commercial software. The direct average, weighted average, and complementary log-log models do not perform as well as the other three mentioned models.

There is an awkward unexplained happening when the generalized linear models are tested using age and race as explanatory factors. The relative errors produced by cross validation are generally larger than the ones produced without the factors.

PUBLICATION:

Read, R.R., "The Use of Survival Analysis in the Prediction of Attrition in Large Scale Personnel Flow Models," Naval Postgraduate School Technical Report, NPS-OR-97-006, March 1997.

DoD KEY TECHNOLOGY AREA: Manpower, Personnel, and Training

KEYWORDS: Attrition Rate Generators, Generalized Linear Models

GROUND WORK FOR RELIABILITY ISSUES RELATING TO NEW JOINT STRIKE FIGHTER

Robert R. Read, Professor
Operations Research Department
Sponsor: Naval Postgraduate School

OBJECTIVE: To prepare reliability calculations needed for the PW-119 engine when used in STOVL aircraft.

SUMMARY: This is an initiation project. Contacts have been established with N88, NAVAIR, and CNA in order to locate materials appropriate to the project. The proprietary nature of the new designs has made it necessary to change to the study of generic problems using information from comparable and abstract systems. Two students have been recruited to spend their experience tours and devote their theses to these problems. Experience tour funding requests have been written.

DoD KEY TECHNOLOGY AREAS: Aerospace Propulsion and Power, Air Vehicles

KEYWORDS: Reliability, Maintainability

LOGISTICS INFRASTRUCTURE AND COMBAT SUSTAINABILITY

David A. Schrady, Professor
Department of Operations Research
Sponsor: Joint Program Office for Special Technology Countermeasures

OBJECTIVE: The objective of the analysis was to demonstrate the relationship between the combat sustainability of naval forces and the logistics infrastructure which supports such forces.

SUMMARY: The analysis demonstrated the dependence of sustainability of naval forces in combat on the logistics infrastructure which supports them. The scenario was the opening phase of the Korean MTW as played out in Exercise Ulchi Focus Lens 96. The Tactical Logistics Support System was used to exercise the forces involved and to estimate their expenditures of fuels and ordnance. Replenishments were made as possible given the Combat Logistics Force ships available and the stocks of fuels and ordnance available at the Forward Logistics Site, the Advanced Logistics Support Base, and in CONUS. Sustainability was gauged in terms of the number of days on which the forces did not have the logistics support needed to remain in action. The analysis also estimated the number of days needed to achieve full logistics sustainability.

PUBLICATION:

Schrady, D.A., "Logistics Infrastructure and Combat Sustainability," Naval Postgraduate School Technical Report, NPS-OR-97-010, May 1997 (CONFIDENTIAL)

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Logistics Infrastructure, Naval Logistics, Battle Group Sustainability

COMBATANT LOGISTICS COMMAND AND CONTROL

David A. Schrady, Professor
Department of Operations Research
Sponsor: Naval Postgraduate School-Institute for Joint Warfare Analysis

OBJECTIVE: The objective of this work was to set out the requirement for logistics information within the command and control system of the joint forces commander.

SUMMARY: Joint doctrine says that commanders must also exercise control over logistics. Control requires information. Logistics is not included in the warfighter's command and control system, but needs to be. Logistics in the Gulf War was examined to identify the kinds of information and planning and analysis capabilities needed. In the Gulf War, the joint forces commander required 60 days of supply be established in-theater. These stockpiles took a long time to establish, created a huge footprint, and represented vulnerabilities. This brute force approach was necessitated by the absence of sustainment planning and prediction tools and the inclusion of logistics information in the command and control system. This work developed the requirement for and some of the characteristics of such a system.

PUBLICATION:

Schrady, D.A., "Combatant Logistics Command and Control for the Joint Forces Commander," Naval Postgraduate School Technical Report, forthcoming January 1998.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Joint Logistics, Focused Logistics, Sustainability

FORWARD ENGAGEMENT REQUIREMENTS FOR U.S. NAVAL FORCES: NEW ANALYTICAL APPROACHES

David A. Schrady, Professor
Department of Operations Research
David S. Yost, Professor
Department of National Security Affairs
Sponsor: Chief of Naval Operations (N8)

OBJECTIVE: The objective was to develop new analytical approaches to defining and articulating requirements for forward-engaged naval forces and to quantify the economic benefits of such forces if possible.

SUMMARY: This project involved three interrelated issues. First was the strategic value of forward-engaged naval forces with a security environment dominated by diffuse, relatively low-level threats, and within an operational environment driven by crises that are difficult or impossible to anticipate. The second issue was the economic benefits of forward-engaged naval forces, as illustrated by the impact of naval force crisis response on oil futures prices during three recent crises in the Persian Gulf. The third issue was the effectiveness of naval forces at providing forward presence, as measured by the amount of coverage or carrier presence in forward areas and by the response times of carriers to widely dispersed locations throughout the world.

PUBLICATIONS:

Brown, R., Lawphongpanich, S., Schrady, D., and Wirtz, J., "Naval Forward Presence Coverage and Response Times," Interim Report, Naval Postgraduate School Technical Report, NPS-OR-97-001PR, 17 January 1997.

Brown, R., Lawphongpanich, S., Looney, R., Moran, D., Schrady, D., and Wirtz, J., "Forward Engagement Requirements for U.S. Naval Forces: New Analytical Approaches," Final Report, Naval Postgraduate School Technical Report, NPS-OR-97-011PR, 23 July 1997

Brown, R., Lawphongpanich, S., and Schrady, D., "Naval Forward Presence Coverage and Response Times," Second Interim Report, Naval Postgraduate School Technical Report, NPS-OR-97-003PR, 5 March 1997.

Looney, R., "Estimating the Economic Benefits Derived from Forward-Engaged Naval Forces," Second Interim Report, Naval Postgraduate School Technical Report, NPS-OR-97-002PR, 28 February 1997.

Looney, R., Brown, R., and Schrady, D., "Estimating the Economic Benefits Derived from Forward-Engaged Naval Forces," Third Interim Report, Naval Postgraduate School Technical Report, NPS-OR-97-007PR, 25 April 1997.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Overseas Presence, Naval Forward Engagement, National Security Strategy

READINESS ASSESSMENT

David A. Schrady, Professor
Department of Operations Research
Sponsor: Deputy Under Secretary of Defense (Readiness)

OBJECTIVE: The objective was to structure measures of military readiness which allow broad discussion of the subject within the military, with the Congress, and with the public at large.

SUMMARY: Though readiness is a commonly used concept, it lacks formal specification and is understood to mean different things to different persons. This state of affairs complicates discussion of readiness and decisions about the level of readiness which should be funded and maintained. The U.S. economy was seen as something which similarly is of broad interest but not formally specified. It was noted that the government established a number of indicators or indices in order to aid discussion and policy making with respect to the economy and that individuals, corporations, and government policy makers find the baseline and trend information in these indicators and indices useful. Readiness indicators were proposed, motivated by the analogy with economic indicators and indices.

CONFERENCE PRESENTATION:

Schrady, D.A., "Readiness Indices," 65th Military Operations Research Symposium, Quantico, VA, 10 June 1997.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Military Readiness, Joint Readiness, Readiness Assessment

BRANCH AND BOUND METHODS FOR SEARCH PROBLEMS

Alan Washburn, Professor
Department of Operations Research
Sponsor: Naval Postgraduate School

OBJECTIVE: Develop and test new bounds to be incorporated in the branch-and-bound (B&B) technique for solving moving-target search problems.

SUMMARY: Several new bounds have been developed and tested. B&B bounds generally benefit from being both sharp (which tends to hold down the number of branches) and fast (which of course influences the computation time per branch). Moving-target search problems seem to have a preference for speed over sharpness; surprisingly simple bounds tend to be winners as far as overall computation time is concerned.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Search, Branch and Bound